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Vegetable and Gardening Tower of Othmar Ruthner in the Voivodeship Park of Culture and Recreation in Chorzów—The First Example of Vertical Farming in Poland

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Abstract: The purpose of this paper is to analyze the possibility of introducing urban vertical agriculture in Poland through the example of the only comprehensively implemented facility of this type so far. Through the example of Othmar Ruthner's no longer existing vegetable and gardening tower in Chorzów, the benefits and damages resulting from an attempt to construct such facilities are presented. The paper also contains an analysis and an attempt to critically assess the phenomenon of the vertical greenhouse that was built in Poland, along with an attempt to assess the real causes of its failure. Based on source material analysis, examples of implementation, and available literature on the subject, an analysis of the possibilities of transforming the facility at the time of its demolition and now was made. The phenomenon of the vertical farm in Chorzów, as a trace of the contemporary architectural heritage of Upper Silesia, is a topic for a broader discussion about the architectural heritage created by buildings which are not so much industrial as technical, with a role so far only secondary to what we call the main architectural functions.

Keywords: vegetable tower; gardening tower; vertical farming; urban agriculture in Poland; vertical greenhouse; Ruthner's Tower; Othmar Ruthner; Chorzów

1. Introduction

1.1. The Idea Upon Boundaries

"We are applying to consent to the liquidation and demolition of the vertical greenhouse built in 1969 in the Voivodeship Park of Culture and Recreation in Chorzów. (...)It is unrealistic in our, and the experts, opinion to use the facility at present and in the future for other purposes. "Mieczysław Hojka [1].

1.2. The Beginning

The vegetable and gardening tower known as Ruthner's Tower was until recently the first and only example of vertical farming in Poland. So far, it is also the only example on a national scale of a facility erected solely for the purpose of conducting vertical crops.

The greenhouse was intended as a prototype facility for vegetable production and flower cultivation. The construction was based on the license of the Viennese company Ruthner

Industrieanlagen fur Pflanzenbau G.m.b.H., equipped with technical devices imported from Austria. The author of the project was a Viennese engineer and pioneer of vertical agriculture—Othmar Ruthner. All the technology and most of the materials needed for construction, along with the design, were ordered and purchased in Austria.

The facility of such importance for prestigious reasons was to be located in the Voivodeship Park of Culture and Recreation in Chorzów (Hereinafter referred to as WPKiW - Wojewódzki Park Kultury i Wypoczynku w Chorzowie)), which was then the main attraction and symbol of the most modern region of Poland—Upper Silesia, an industrial heart of the country (Figure 1). Chorzów is a part of the Upper Silesian conurbation (currently the Upper Silesia-Zagłębie Metropolis, called GZM) and with its other cities (such as Katowice, Gliwice and Zabrze) it forms a complex urban organism, which after World War II was an important industrial center of the country. Therefore, social, urban and historical processes are considered in the article in a wider context. Prestigious investments undertaken in cities such as Chorzów, Katowice and Gliwice influenced the overall architectural vision of the state authorities during the communist period for Upper Silesia. Architecture in the region is often considered in the context of many cities [2].

Figure 1. A view of the Voivodeship Park of Culture and Recreation in Chorzów—the postcard showing the area of the National Horticultural Exhibition, 1967–1968. On the left—the vegetable and gardening tower (on the basis of [3]).

1.3. The History of Urban Vertical Farming in Poland

The history of vertical farming in Poland is quite short and basically includes the building of two facilities. No longer existing, the so-called Ruthner's Tower can now be considered as a historic monument. Contemporary urban vertical farming in an industrial form in dense downtown areas is in the early stages of creation. So far, in 2015 the Urbanika Farms enterprise started operating, using the rooms of the Faculty of Biotechnology and Horticulture at the University of Agriculture in Krakow, and crops (mainly micro-herbs and sprouts) are sold in Krakow, Warsaw and Wroclaw and available to restaurants in Lesser Poland [4].

1.4. Origins of the Concept of Vertical Farming (Basic Typological Division)

Vertical agriculture, based on the definition by April Philips, is food production (cultivation) in a vertical arrangement [5]. It is possible to achieve by using soil or hydroponic systems, in the form of free-standing (independent) facilities or related to other forms of architecture. One of the first attempts, in the modern sense of the term, to define the concept was made by John Hix in 1974, describing it as growing plants in tower greenhouses or on vertical surfaces [6]. Modern technology uses cultivating methods known from traditional greenhouses, where natural light can be enhanced with artificial lighting. An attempt to define the concept in Polish conditions was made by Bogusław Wowrzeczka [7] (p. 86), describing modern vertical farming as environmentally friendly, compatible with current technology and knowledge, and economically profitable growing of plants or raising of animals in multi-story buildings, skyscrapers or other inclined surfaces. He also drew attention to the complex, although from the current perspective—very incomplete, typological division of vertical urban farming resulting from a number of factors such as form of cultivation/farming, the adopted production technology, location, spatial forms of the facility and the possibility of using existing facilities for new purposes in the revitalization processes [7] (p. 87).

Although some researchers associate the genesis of urban agriculture/vertical farming with the legendary Hanging Gardens of Semiramis [8] (p. 40), the publication of "Vertical Farming" in 1915 by Gilbert Ellis Bailey [9] is a much more clear and more modern turning point [10]. Despite its title, now clearly understood as multi-level above ground agriculture, Bailey's work was not concerned with overground, but underground farming, which could be introduced in cities thanks to the widespread use of explosives.

Not much later, a number of theoretical considerations were soon continued in the implementation of vertical farms using either hydroponic technology or soil cultivation [10]. The tower in Armenia is probably one of the first, yet no longer existing, hydroponic vertical farms, erected probably before the year 1951 [11]. Not much later, the prototype of the Chorzów tower was build [12] (p. 60).

The first contemporary definition of the spatial features of vertical agriculture was possible due to the work of Dick Despommier, who clearly assigned it the most contemporary of urban functions related to work places—office tower buildings [13], making them the carrier of the idea of sustainable development, the use of alternative forms of electricity, gas supply, etc., the same as food production. Due to the fact that currently the understanding of assumptions of urban vertical agriculture has significantly expanded, nowadays it is being considered together with its social, economic and ecological context. Therefore, the tower constructed in the zoological garden in Paignton in the United Kingdom is considered to be the first modern indoor vertical farm (finished in 2010). It is a place of animal food production and a place of research on the issue of urban agriculture [12] (p. 61).

The basic typological division of vertical farms was made by the type of farming system into hydroponic, aeroponic and aquaponic agriculture. Birkby also divides it according to the type of structure for selected systems. These will be built-in farms or container farms [14]. On the other hand, Małgorzata Drożdż-Szczybura points to the distinction between open farms (now often mistaken with the so-called raised beds, usually implemented in very traditional forms) and indoor farms, with fully controllable environmental conditions and life cycle [8] (p. 42). It is also crucial to distinguish between the way of defining urban vertical agriculture/vertical farms and the so-called vertical gardens. Very often these terms are used interchangeably, although it would be rather appropriate to assign the name of vertical gardens to green wall systems enabling vegetation of edible or decorative plants in an external environment, in special containers allowing their maintenance-free functioning [15].

In this case, Christine Loessl's interpretation of the definition [16] should be adopted as a relatively new field of highly mechanized urban agriculture that uses farming techniques in a controlled environment (CEA—Controlled-Environment Agriculture) through the use of artificial lighting in multi-level systems. Vertical farms can be designed as unrelated to the local climate, solar lighting or the region, creating optimal climatic conditions for local production of high-quality food in a 24-h and year-round system.

2. Materials and Methods

Source material analysis, including preserved design documentation of Ruthner's Tower in Chorzów, as well as documentation from the facility operation, technical expertise and preserved correspondence between contractors, designers and facility users, was used as the main research method. The method of comparative analysis in the context of historical implementations of facilities designed by Othmar Ruthner's office or with the same agricultural function, existing or only designed for different urban areas, was used as a supplementary method. The conducted research is causal and concerns a narrow scope of the investigated phenomenon—vertical urban agriculture. As a kind of monographic research, it concerns only one building, located in the context of the region and compared with the work of their designer realized in other parts of the world [17,18]. The method of mixed—historical and interpretative—research [18] (pp. 159–160) was connected with case study analysis and included collecting and archiving historical data, both empirical and archival, their organization and evaluation; it was also connected with multiplied and simplified research of other, also non-existing buildings built by Othmar Ruthner. The adopted methodology is customary in architectural and historical research [18] (pp. 187–189).

An archive inquiry performed in February 2017 in the Archives of the Silesian Park—former Voivodeship Park of Culture and Recreation S.A. in Chorzów, ul. Siemianowska 78, was the basic part of the conducted research. Collected archives included architectural as well as technical and construction drawings, technical studies, expertise, original designs performed by the Othmar Ruthner company in Vienna, as well as Polish translations of the correspondence between Othmar Ruthner and the investor. The archival documentation of the tower came from the years 1964–1984.

The analysis also included source materials from the local press from the times of the establishment and operation of the facility available in electronic archives, including the now-defunct daily newspaper Trybuna Robotnicza, published in Silesia, which was one of the largest regional newspapers in the country. The analysis of historical press materials made available in the Silesian Digital Library allowed to define a broader social and economic context of the establishment and functioning of the facility in the first years after its construction.

At the same time, unpublished data from Austrian and German archives documenting Othmar Ruthner's oeuvre and the history of urban agriculture were also collected, with the large help from the Lubera Edibles GmbH in Bamberg.

3. Results

3.1. Ruthner's Tower

"Turmgewachshaus", as a production line system for a fresh vegetable and fruit factory, was developed in its best-known form by Othmar Ruthner. It combined the latest at the middle of 20th century hydroponic technology, enabling soilless cultivation with the technology of a fully automated production line, which in American publications on this subject was compared, not without reason, to the General Motors production line [16]. Eberling mentions experimental hydroponic towers built by Ruthner in Oberlaa Park in Vienna and Grossenzersdorf near Vienna, and a small tower in Iran producing peppers and tomatoes in an area with climate and soil preventing any other agricultural production [19].

The decision of where to locate one of the towers in Chorzów was directly influenced by the Vienna International Horticultural Exhibition (Wiener Internationale Gartenschau—WIG) in 1964 and the construction of one of the accompanying facilities—the so-called Donauturm, a transparent vertical greenhouse by Othmar Ruthner. The press from that period reported huge interest in the matter, which resulted in 1965 in the construction of more than a dozen similar towers, including four in the Federal Republic of Germany and in West Berlin alone [20], and required the use of facilities for experimental cultivation in Technische Hochschule Hannover, Berliner Technische Universität and Bayer-Pflanzenschutzabteilung (Figure 2). An article from 1965 mentions the experimental tower

having just opened in the Bayer-Werke research garden in Leverkusen [20]. The tower concept had two variants of height—the lower one, about 14.0 m high, intended for 480 shelves or 9500 pots, and the higher—about 40.0 m high.

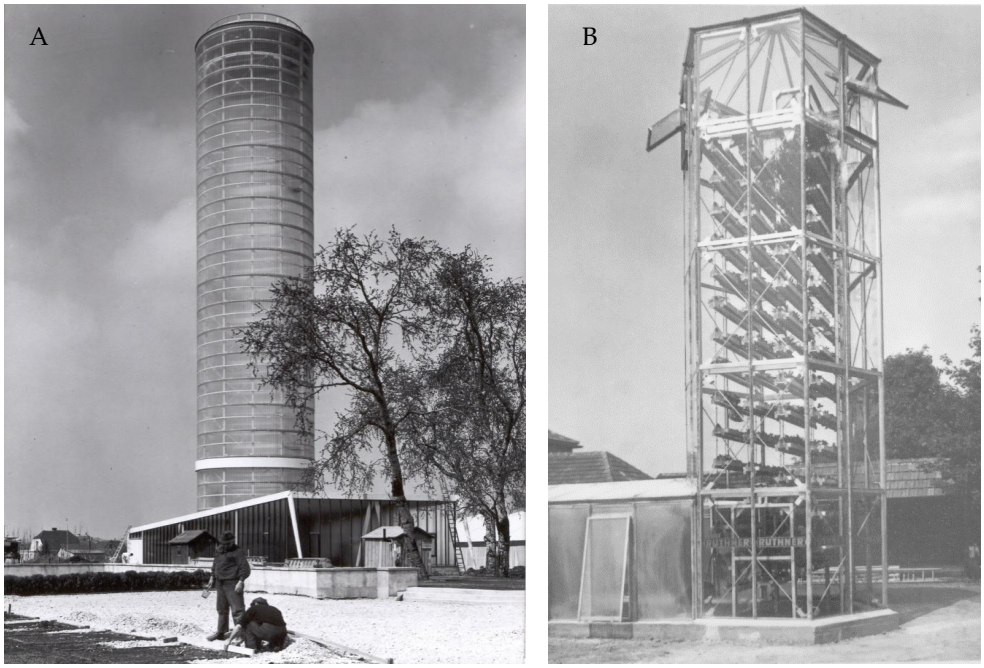

Figure 2. (**A**) A view of the gardening tower at the WIG 64 exhibition in Vienna, 1964. (**B**) A view of the gardening tower, 1963. (on the basis of [21] (p. 42)).

The optimism which accompanied the possibility of intensifying cultivation while limiting the necessary area allowed Ruthner to claim that in the near future the traditional form of soil-based agriculture will be practically abandoned in favor of multi-level solutions [22] (p. 4). When the new idea of automated agriculture appeared, the frequently recurring argument was the possibility of a significant reduction in the number of people necessary to support it (even to one person per tower) and a definitive break with climate restrictions, which were to be solved by the city-wide indoor agricultural system related to the Danube River running through Vienna [19]. The facility, which was supposed to be the realization of an utopian, as it was thought at the time, vision of the role of urban greenery in the well-being of urban habitants, produced fresh food for the needs of eight restaurants located in the area of the WIG exhibition [21]. After the completion of WIG 64, the tower was dismantled [23].

3.2. Overview of Completed Gardening Towers Designed by Othmar Ruthner

Analyses covering all of Ruthner's gardening towers do not fall within the scope of this article. This paper attempts to outline the context of functioning of Ruthner's towers on the basis of available data. This makes it possible to compare the gardening tower in Chorzów with other examples, especially in terms of analysis of the tower's failure in Silesia.

As mentioned, the expectations and hopes for the greenhouse towers were enormous. *Spiegel* and *The New York Times* described them as the introduction of agriculture into the new era [20]. In 1978, *Popular Science* was wondering whether such towers would not become part of supermarket equipment [19]. Utopian dreams of providing fresh vegetables and plants produced close to people's homes, freedom from climatic conditions and hard work on the land caused the towers to be built in various places around the world, including Austria, Germany, Sweden, Italy, Norway, Russia, Canada, Libya, Iran, Japan and Poland [24]. The research work on the number of completed towers is incomplete and according to various sources their number was 24 [24] or 29 [5]. Moreover, there is

a lack of precise data and research on the way they functioned. It should be noted that the authors have not found an example of a contemporary working gardening tower designed by Othmar Ruthner. Many of the towers were partially or completely demolished and Ruthner's company stopped the development of the idea in the 1980s [23].

The towers that were built had different applications. Universities in Hannover, Berlin and Bayer Plant Department used them for research and experimental plant growing [20]. The Bayer towers were demolished in the 1980s [25]. Some of the other towers were used to produce food for humans and/or animals [22]. According to the 2003 reports, the largest greenhouse tower was located in the Libyan desert. It was used to produce 10 tons of green fodder per day, which provided a supply for 350 cows. In turn, the low tower built in Iran produced vegetables (peppers, lettuce and tomatoes) in areas that did not allow traditional cultivation, to which vegetables had to be specially transported [24]. It was in such areas, where traditional cultivation would be very difficult and expensive, that the greatest commercial potential of the solution was seen [20]. One of the first industrial applications can be found in Germany—horticulturist Robert Mayer cultivated primrose and cyclamens in Bamberg [20]. According to the authors' findings, the tower does not exist anymore.

Probably the first two gardening towers designed by Othmar Ruthner were built at the Langenlois Gardening School in Austria. The first tower was built in 1963 and the second in 1964. The first one had a hexagonal plan, a height of 11 m and was encased in transparent glass. It was equipped with a circulation system for seed boxes. Its position in relation to the cardinal directions made the chain of the circulation system at the southern wall heat up disproportionately in relation to the chain at the northern wall. This caused the heated chain to fall out frequently from the reel and parts of plants in the boxes to fall out. For this reason, the tower was used as a tall greenhouse to grow climbing plants and deteriorated with time [23]. In the 1990s it was dismantled and taken over by the school graduate to use for his own horticulture. The second tower, from 1964, had a circular plan, 22 m height and polyester-panel cladding. The circulation system was equipped with flowerpots and its chains were placed along the eastern and western walls, solving the basic problem of the first prototype. The height of the tower caused significant temperature differences between the base and the upper part of the tower, which exposed the plants to constant temperature changes. The building was in use until the 1990s and in 1998 it gave way to new school investments. The structure was dismantled and sold for scrap. There was also a tower in Imst in Tirol, but the exact details of the tower were not preserved. In the 2006 demolition documentation for the new investment outline, only the hexagonal plan of the glass tower was marked for demolition [23].

Ten years after the exhibition, which presented the most famous tower designed by Ruthner, another one was built not far away. At the WIG 1974 exhibition in Vienna, Othmar Ruthner presented a newer version of his project. However, the building was forgotten and destroyed after the exhibition. Today the only remnant of the tower is a steel scaffolding. The technical devices and the glass casing have been removed [26]. The steel skeleton has become a place of tourist excursions and a point of interest for the subject related to the future of vertical farming [23,26]. In the years 2019—2021, work on revitalization of the tower as a research facility for Austrian start-ups dealing with vertical farms is undertaken:

The core of this study is the measurement of energy and material consumption of food production, the influence of the building shell, high- to low-tech decisions, the actual energy, land and water consumption and consumption of fertilizers, herbicides, fungicides and pesticides [27].

According to Werner Sulzgruber's research [22,23], the longest working Ruthner gardening tower in Austria was located in Wiener Neustadt. It functioned from 1965 to 2006 and was, until its demolition in 2017, the last tower with the original shape and equipment designed by Othmar Ruthner. The authors of the paper have not found a source indicating the longer-preserved Ruthner Tower in the world. The vertical greenhouse in Wiener Neustadt is part of the WIG 64 period and was built in 1964/65. The tower was built at Konskryptsnummer 7 by Othmar Ruthner's company. All architectural drawings are dated between 5–27 November 1963. The instruction manual is dated

3 July 1964, the static calculations are dated January 1964. The building was commissioned in 1965. The building had a hexagonal plan with a side length of 1.65 m. The six walls consisted of two glass elements on almost every level. The tower was made of rolled sections (wall transom frames) set at intervals of about two meters, with the highest ring intended to hold the roof. The steel structure had a total of five levels and a height of about 10.5 m. The usable area of the building for cultivation was about 60 m^2. The steel supporting structure consisted of vertical columns with special gutter profile connected by horizontal rings of the tower. The tower was glazed, and the glass was assembled without the use of putty but with profiles of galvanized steel sheet. The roof was designed as a polyester dome. The circulation system consisted of galvanized chains, rope pulleys with a diameter of about 50 cm, screws for fixing the plant hangers and a drive with a small 0.25 KM motoreducer. The chains moved continuously forward through three rollers on each side at the lowest level and through two rollers on each side at the highest level. Iron hangers or grates for plant transport were anchored between them. They were set up along the East-West axis so that the solar energy could affect the plants moving from top to bottom in a cycle for as long as possible. The circulation speed was about 1.8 m/min, and the full time was about 20 min. Pots, bowls or flower boxes could be placed or hung on the grates. In total, 72 or 126 grates could be used. With 72 hangers, one measured a maximum of 40 × 168 cm and had a load capacity of 25 kg. The total weight of the load was 1.8 tons. The heating of the tower was provided by means of an air heater, which was mounted on the floor and directed upwards. The air was heated by a hot water supply. The GEA-Multi-Therm fan directed the heated air up along one side of the tower, after which, due to its cooling, it fell on the opposite side of the room, where it was sucked by the heater and blown up again. A 380 W three-phase motor supplied energy to the air heater, and the boiler system guaranteed the required 90 degrees Celsius for the hot water coil. Ultimately, the heat demand was calculated at 21,000 kcal/h (=24.4 kW), with the temperature difference of 40 degrees taken as the basis for calculations (at −20 outside and +20 degrees Celsius inside) [22]. Compared to the huge Ruthner towers built in Vienna, as well as in Chorzów, the low tower in Wiener Neustadt had the advantage that the demand for thermal energy and drives was relatively low. This probably explains the fact that this urban vertical greenhouse operated for so long [22]. The tower was dismantled in 2017 to free up space for a new investment. Through social activists, it was established that it would be rebuilt in a new place in memory of Othmar Ruthner and his invention [28].

3.3. Reasons for Construction

To understand the phenomenon of Ruthner's Tower in Chorzów, it becomes important to analyze the very reasons for its construction. Although at a first glance it seems that this decision was mainly due to ambition, the truth is much more complex. After analyzing the available source materials, the reasons for construction of the first, and so far the only, vertical greenhouse in Poland can be divided into several groups, classified into ambitious, political and economic categories on various scales.

An unquestionable inspiration and a direct impulse for the construction of the tower was the opening of the WIG 64 gardening exhibition at the Donau Park in Vienna and, therefore, the existence and functioning of an almost identical facility [28,29]. Considering this on a global scale, the Viennese tower instantly became a symbol of prestige and modernity. The same effect was expected to be obtained in Poland, as a symbol of modernity and power of the industrial region of Upper Silesia (Figures 3 and 4).

At the same time, however, such an innovative solution could solve the problem of access to fresh food for the inhabitants of Upper Silesia for whom, at the time of very strong development of coal mining and other forms of heavy industry in the Upper Silesian agglomeration, this access was significantly reduced [30,31]. Another important aspect is that a significant degree of environmental pollution (mostly of soil and air) [32], especially with heavy metals, hindered and limited the possibility of developing traditional soil agriculture in the region; therefore, the area became dependent on external food supplies. Therefore, there was a need to increase the availability of fresh vegetables in the Silesian conurbation, as the most dynamically developing and priority area for strategic reasons

in Poland and relatively distant from cultivated areas. It became necessary to search for solutions suited to the adverse environmental conditions in the region. In this situation, the Austrian solution of soilless cultivation carried out indoors, in addition to the obvious benefit of accelerating the process of plant growth (at the beginning of the exploration the process was statistically shorter by approximately 30% compared to analogous growing plants in greenhouse facilities), also gave the opportunity to quickly test the usefulness of solutions of this type for the needs of specific Upper Silesian conditions.

Figure 3. A plan of the Voivodeship Park of Culture and Recreation in Chorzów. No. 20, on the south site of the park—the gardening tower (H)—the area of gardening exhibitions. The tower was located at the highest and central point of the southern section of the park, between the Silesian Stadium (A) and the fairground (J). The image illustrates the park in about 1972 (developed by the authors on the basis of [33]).

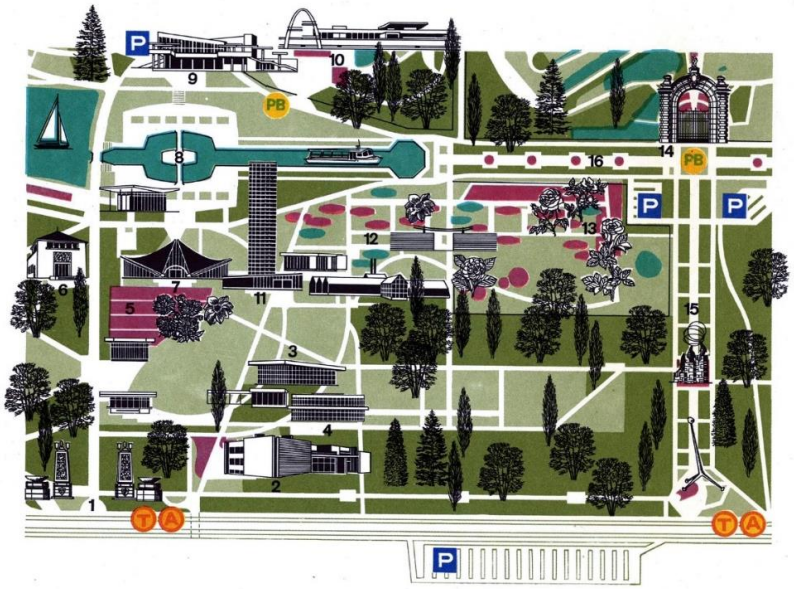

Figure 4. Site plan showing the location of the vegetable and gardening tower. No. 11—the gardening tower. The image illustrates the tower in about 1972 (developed by authors on the basis of [33]).

For more prosaic reasons, considered on a local scale—locating WPKiW in Chorzów, as the largest park in the voivodeship, also required providing agricultural and technical facilities, which were implemented in the farm building for years.

3.3.1. Why Is Vertical Farming Important in Upper Silesia?—Basic Data

It is also worth considering why, apart from the ambitious issues, exploring the possibilities of implementing urban agriculture in Upper Silesia was considered. Apart from the choice of location in the city park, which reveals a very simplified and brief perception of vertical agriculture, associating it only with greenery and greenhouses, the choice of land was dictated by practical reasons.

Agriculture in the Silesia Voivodeship is characterized by specific features, for Polish conditions, and at the time period under analysis it functioned in more extreme conditions than it does now. Now, the area of agricultural land in the voivodeship is 389,435 ha (39.4% of the total area) and is the smallest in the country [34], with the national average being 931,506 ha. At the same time, due to significant population density and a very high urbanization index, the area of agricultural land per one inhabitant is only 0.11 ha (the national average is 0.42 ha) [32].

The number of people working in agriculture (as of June 2007) was only 289.7 thousand, of which people working in individual farms were 288.9 thousand; meanwhile, according to the actual workplace and since 2004 by the type of activity, in 2007, less than 68 thousand people worked in agriculture [35]. In 2013, the number of full-time employees, including the contribution of permanent, casual, contract and others, as well as the neighborhood aid, amounted to 65.7 thousand and is constantly decreasing [36]. Analyzing the averaged data, the number of people employed in agriculture amounted (average in the years 2011–2013) to 86,877 persons, with the national average being 144,735, and the area of agricultural land per one employed person [ha/person] was only 4.7 with a national average of 8.6 [33,37].

In the whole group of agricultural products, vegetable production is, and always has been, very low in the Silesian Voivodeship—9% [38]. The province's agriculture currently satisfies 39% of the demand for vegetables [38]. Most of the voivodeship area has unfavorable or very unfavorable conditions for agricultural development. The distinguished groups cover the majority of cities and are generally connected by their proximity in geographical space. These include the Rybnik agglomeration, mountainous areas, and areas in a wide zone marked by the railway line Częstochowa-Zawiercie-Katowice. These parts of a land include the so-called problematic agricultural areas (Jurassic and Carpathian), classified by Bański [39], which are characterized by an accumulation of negative socio-economic or natural phenomena that make them disadvantaged in relation to others and weaken the lands' agricultural function

At the same time, a very important problem of this area for the development of traditional agriculture is the significant soil contamination as a result of very intensive industrial and mining activities over the years, which cause the incorrect conditions for growth and development of most arable crops [30]. Therefore, the majority of researchers postulate the exclusion of root and leafy (traditional—ground) vegetables in this area, as there is a serious risk of contamination of all types of plant crops growing on contaminated soils [40].

3.3.2. Case Study—Traditional Agriculture and Hydroponic Cultivation in the Ruthner Tower

This analysis presents simplified data on the yields and workload that can be achieved in Poland, in Upper Silesia, in the case of traditional tunnel cultivation and cultivation in Ruthner's vertical greenhouse. The actual parameters shown in the documentation of the building from the period of its exploitation and the data characteristic averaged on the basis of [42] for the cultivation of butter lettuce, which is a typical vegetable available and popular both nowadays and in the years of the tower's operation in Chorzów, were used for this simulation (Table 1).

Table 1. Simulation of the production volume and labor input for the production of 1 kg butterhead lettuce in traditional tunnel farming and in a greenhouse tower. Data on traditional cultivation based on [41].

	Tunnel Tillage	Vertical Greenhouse
Average production volume	2.67 kg/m^2	
Crop area	100 m^2 of land	1200 m^2 with a development area of 100 m^2 *
Vegetation period	8 weeks	70% of 8 weeks
Numer of cycles	3	52/(0.7 × 8) = 9
Production volume in the year	3 × 2.67 kg/m^2 × 100 m^2 = 801 kg	9 × 2.67 kg/m^2 × 1200 m^2 = 28,836 kg
Workload in man-hour/1000 m^2 per harvest	325 man-hour/1000 m^2	Permanent employment of 2 workers
Workload in man-hour/1000 m^2	325 × 3 = 975 man-hour//1000 m^2	2 ** × 2024 = 4048 man-hour//1000 m^2
Workload per man-hour/kg	975/(801 × 10) = 0.122 man-hour//kg	4048/(28,836 × 10) = 0.014 man-hour//kg

* without taking into account the economic and social area, which gives a total area of 22 × 25 m, for lettuce the so-called low cultivation with a higher density of shelves was adopted. ** two shifts were assumed; one worker was needed to handle the agricultural production in the tower.

The vegetation period of butter lettuce was estimated at about 8 weeks. The average size of world production is 2.16 kg/m^2, in the USA—3.54 kg/m^2, and in Spain, which is the largest European producer—2.67 kg/m^2. The latter value was used in the calculation.

As this simplified simulation has shown, agricultural production in Ruthner's Tower would yield almost 30 times the yield of land-based agriculture. This is due to a number of factors, ranging from the acceleration of plant growth in hydroponic tower tillage to more than 3 times the vegetation cycles, which in this case can take place all year round. Another advantage in this case is the complete isolation from the external parameters of the environment, which is very important in the case of plants accumulating heavy metals, and therefore not being suitable for cultivation in a polluted environment.

This analysis has also shown that the workload per production volume is almost 10 times lower in the case of vertical greenhouses. It should also be remembered that in the case of closed crops, this structure looks even more different, as the operation of the crop zone itself requires work in two shifts (only in daylight), so the whole building can provide employment for two people, which means that relatively few workers are needed. In the case of traditional crops, the workload is similar, but is limited to only one third of the year, so at the same time it requires temporary employment of six–seven people, who later need to find employment elsewhere. As we can see, the model of built-in agriculture gives meaning to a better structure and stability of employment, at the same time not involving a large number of people, which in the current situation of an employment crisis is of tremendous importance in ensuring food supplies in a crisis situation.

3.4. Construction of the Facility

The concept design for the tower was prepared dually. The Polish architectural, construction and technological design and site plan were prepared basing on the project presented by Ruthner Industieanlagen für Pflanzenbau located in Vienna, written in German. Then it was translated into Polish and adapted to Polish design standards, located on a site in the Silesian Park in Chorzów by Polish the Design and Implementation Office for Investments in Chemical Raw Materials Mining "Biprokop" (Biuro Projektów i Realizacji Inwestycji Kopalnictwa Surowców Chemicznych "Biprokop") from Chorzów. The main designer from the Polish side was Eng. Jan Leżoch, checking was made by Mgr. Eng. Józef Wargala, with the head of the design studio Eng. Ignacy Zygmunt.

According to a technical description prepared in July 1981 for the needs of the developed expert opinions, the vertical greenhouse complex consisted of the main greenhouse building and the so-called

base surrounding the main one-story facility, housing the laboratory, wardrobe, sanitary facilities, as well as work and utility rooms (Figure 5). The final functional and spatial program is listed in Table 2.

Table 2. Final functional and spatial program of Ruthner's Tower and accompanying facilities at the Voivodeship Park of Culture and Recreation in Chorzów; state from 1983.

The Base Building for the Tower		
ground floor	work room	22 × 10.9 m
	main laboratory	4.05 × 3.7 m
	dressing room with lavatory	3.7 × 2.75 − 1.6 × 1.1 = 8.42 m^2
	toilet	1.1 × 1.6 = 1.76 m^2
	tower base room	22 × 14 − 3.8 × 7= 281.4 m^2
basement	storage for containers for watering solutions, distribution of heating devices, cold and hot water and pumping system	4.5 × 7 m
Pavilion		
greenhouse for exhibitions and planting		120 m^2
dressing rooms and sanitary facilities for employees (5 women + 5 men)		according to building standards
dining room for employees		
manager's office		
storage with box for fertilizers and chemicals		30 m^2
peat storage		
the watchman's room		
laboratory and 2 laboratory rooms		(12 + 25) m^2
gas boiler room		
A room for greenery with a separate entrance [1]		
locker—room for 20 females		according to building standards
locker—room for 5 males		
foreman's office for 2 people		
sanitary facilities (toilets and wash basins) for women		
sanitary facilities (toilets and wash basins) for men		
dining room for 25 people		
tool storage × 2		2 × 15 m^2
common storage—mower and fuel		15 m^2

[1] According to the guidelines of 7 November 1975.

The vertical greenhouse of the "Ruthner" Industrieanlagen fur Pflanzenbau G.m.b.H. company structure, Wien II, Austria, year of manufacturing 1966, had the shape of a cylinder with a diameter of 11 m and a height of 54 m. The supporting structure of the tower was a steelwork, protected in 1979 with paint coatings—chlorinated rubber enamel.

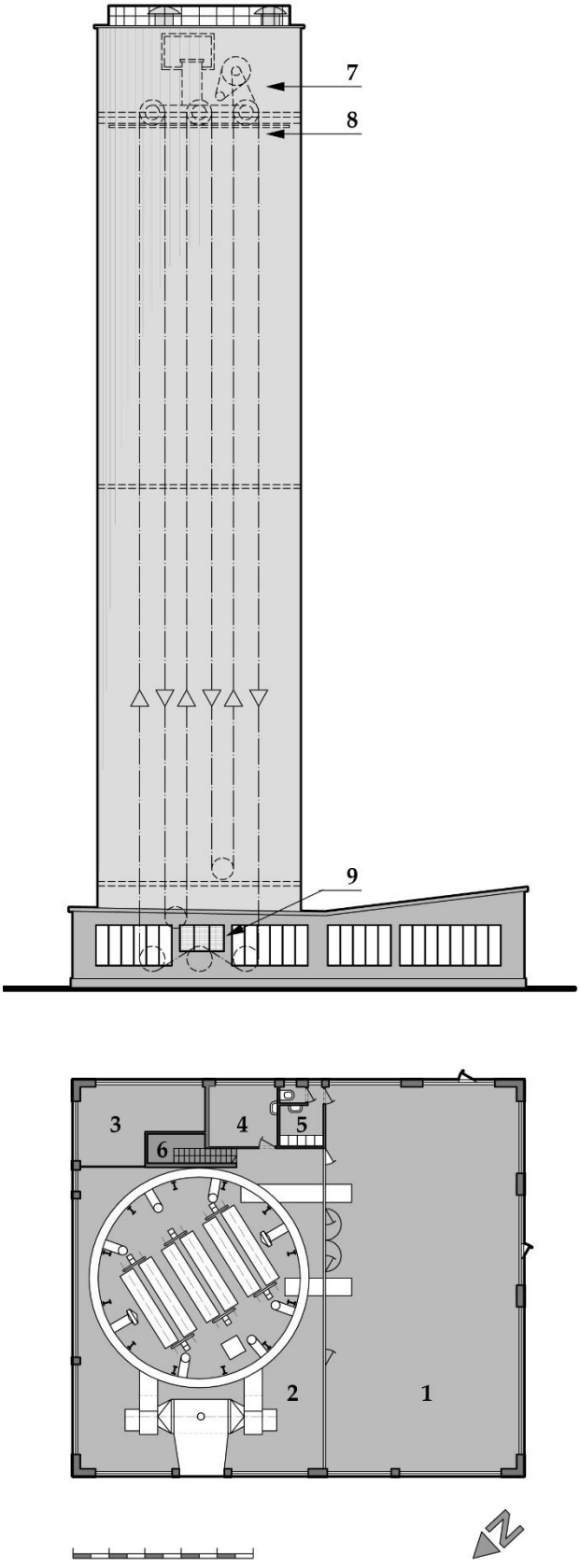

Figure 5. North-western elevation and ground plan of the gardening tower. A state from May 1966. 1—main work room, 2—tower base room, 3—main laboratory, 4—dressing room, 5—lavatory and toilet, 6—basement, 7—drive for circulation device, 8—humidification device, 9—sprinkler (developed by authors on the basis of [42]).

The mechanical system enabling production was relatively uncomplicated and consisted of the following main elements:

- The propulsion system located on the top of the 54-m tower consisted of an electric motor connected by an electric clutch equipped with an electrically operated drum brake with a single-stage transmission, which in turn, by means of a friction clutch, is equipped with a device protecting against overloading of the main double drive gear wheel. The double sleeve brake system transmitted the drive to three drive wheels of the transport chain.
- The transport system consisted of two parallel working sleeve chains of equal length, closed and working in a system of three upper gear wheels, four lower gear wheels and one lower tension wheel. The chains were equipped with a sling placed at intervals of 1.0 m, from which transport baskets for plant production were suspended. The chains were guided in anti-rolling guides, and the possibility of current tension adjustment was ensured by the screws of foot-operated gearwheel suspension.
- The lubrication system covered 35 points, while the load chain was lubricated automatically by means of a separate system equipped with a pump and two sets of check valves located on one of the lower tensioning wheels for each chain.
- The lighting system consisted of five separate lighting lines.

Each of the chains could be moved manually with a crank. However, as described at the beginning of the 1980s, the chain system was virtually no longer used at that time and was therefore stuck and difficult to operate.

3.5. Technical Specifications

- Type of growing system—hydroponic (peat).
- Total height—54.00 m.
- Outer diameter—11.20 m.
- Usable floor area—100 m^2.
- Main shaft mounting height—50.92 m.
- Height of the upper working platform and installation of the drive—48.23 m.
- Produced in Poland Indukta domestic engine and gearbox.
- Maximum weight per basket—230 kg.
- Permissible chain strength per string—6200 kg.
- Two-row roller drive chain with increased strength, payload—114,000 kg.
- Sleeve chain/rollerless/single-row "Fissenswert".
- Payload by manufacturer—35,000 kg.
- Number of slings—shelves—285 pieces.
- Cultivation area—1200 m^2.
- External dimensions of the base building—22.00 × 14.00 m.

3.6. Final Functional and Spatial Program

The functional and spatial program of the facility developed throughout the years of its utilization. The first and the oldest part—the base building for the tower (and the gardening tower itself)—was divided into two stories. Other buildings were designed to suit the growing needs of the Park and decreasing efficiency of the plant indoor production. The so-called pavilion and a room for greenery with a separate entrance were designed mainly for the purpose of exhibiting plants and to suit the needs of an increasing number of employees—gardeners and technicians.

3.7. Construction's Timeline

- 28 April 1966—technical documentation for the project received in a translated version from German.
- 25 August 1966—submission of final documentation by the Austrian designers.
- 8–9 October 1966—first press information about the construction of a vertical greenhouse in the local press [43].
- 6 December 1967—Design of the green area surrounding the Exhibition Hall and Ruthner's Tower, Department of Landscape Architecture at the Warsaw University of Life Sciences—SGGW.
- 28 February 1967—*Trybuna Robotnicza* No. 50/1967 reports on the ongoing assembly of Ruthner's Tower's structure as the largest structure of this type in the world [44] (Figure 6).
- *23 June 1968—ceremonial opening of the vertical greenhouse during the Polish Horticultural Exhibition–OWO-68 [45].
- 5 January 1983—the last preserved papers of the WPKiW board regarding the possibility of adaptation or renovation of the tower addressed to the Ruthner company.
- 8 June 1984—the last piece of press information about the upcoming demolition date of the tower [46].

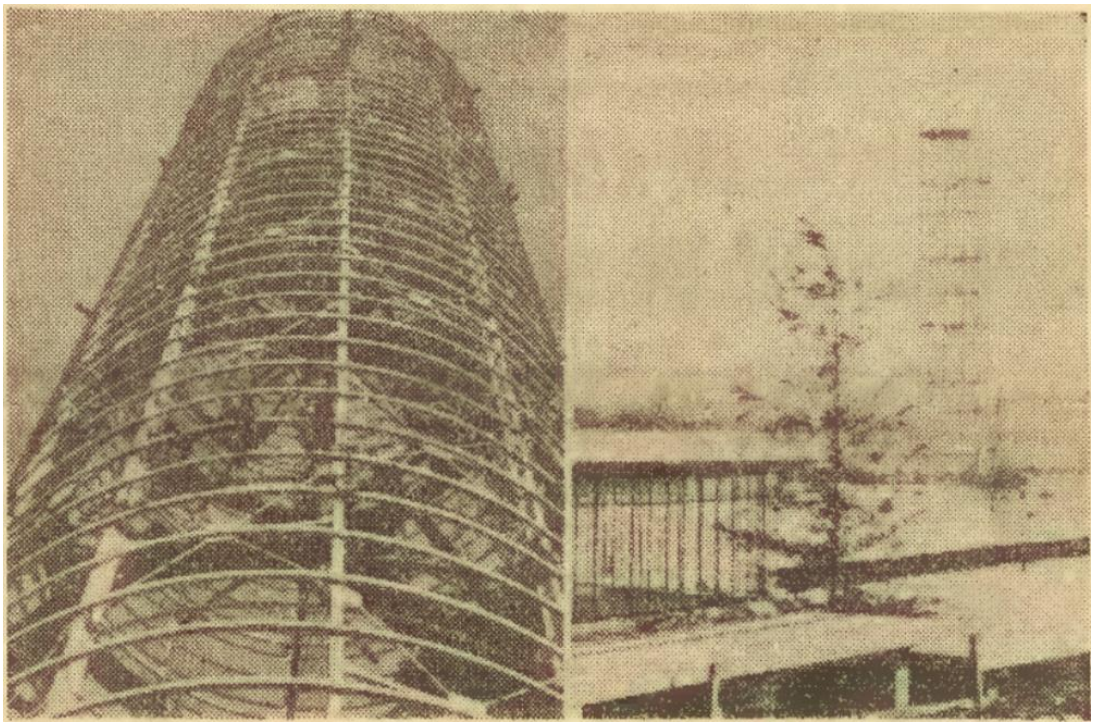

Figure 6. Photo material from the time of constructing Ruthner's Tower in the Voivodeship Park of Culture and Recreation in Chorzów, published in the local press in 1967 (on the basis of [44]).

3.8. Causes of Demolition

In a letter from 1983 [47] addressed to the Ruthner Industieanlagen für Pflanzenbau, the following reasons of making an attempt to repair and reorganize the tower were mentioned. These included primarily the impossibility of horticultural production caused by the reduction of light transmission through the outer coating to 22% (according to the research conducted in 1980).

The reason for this was the corrosion of the Austrian "PWS" polyester sheets forming the casing of the greenhouse. It was caused by exposure in conditions of high dustiness and air pollution from SO_2, SO_3 and other substances in the air, which was directly caused by being in the vicinity of a large

number of mines, steel mills and power plants in the Upper Silesia region. As further mentioned, attempts to wash and to coat the casing with protective paint did not give the desired result. One of the reasons for this was also the erosion of panels as a result of high humidity inside the greenhouse, condensation of water vapor and internal stresses in panels resulting from strong wind pressure.

In earlier documents (expert opinion from 1975 by the Building Research Institute in Warsaw [48] and expert opinion prepared by the Polish Academy of Sciences, Department of Polymers in Zabrze in 1979 [49]), it was found that the panels were heavily contaminated, which caused an almost complete lack of natural lighting in the greenhouse and matting of the surface of external panels, increasing the visibility of fiber reinforcement glass and exposing the fiber on both sides of the plate, cracking and crumbling of the resin surface, chipping of gaskets between plates, and, subsequently, the fragility of the plates causing the formation of fractures ca 25 mm, longitudinal and transverse cracks due to strong winds and the falling off of fastening plates to the steel structure.

The justification also included the lack of an answer as of that time (beginning of the 1980s) about the condition of other vertical greenhouses designed by the Ruthner company from the early 1960s. No information was obtained regarding the possibilities and efficiency of actual adaptation of this type of facilities located in the world for other purposes, while there was no reliable price estimation for replacing the greenhouse external panels.

In 1974, some design solutions from the vertical greenhouse were planned to be used in the construction of the facility of the Institute of Binding Building Materials Industry (Department of Environmental Protection of the Białe Zagłębie) in Opole. Therefore, some correspondence regarding the loan of the design documentation from the end of the year has survived.

In a letter from July 1981 [50], it was confirmed that it was impossible to produce elevation panels with similar parameters on the domestic market. The only solution was to order them from abroad, with the cost of delivery alone estimated at 40,000 dollars, and the cost of renovation, replacement and fastening estimated at several million zlotys.

Operation of the building in the years 1970–1980 did not confirm assumptions which led to the decision to construct the tower. During this time, the greenhouse was to generate significant financial losses. In a letter from 1983 [51], director Hojka showed an annual deficit of PLZ 1.9 million (this is currently the equivalent of about 260,000 PLN (2019). PLZ was the official currency of Poland before 1995, when the currency underwent redenomination. 10,000 old złoty (PLZ) became one new złoty (PLN)). Further operation would require securing significant financial resources (in PLZ and foreign currency) and renovating the facility.

Expertise no. 60/K/82 prepared by the District Agricultural and Consultancy Center (OORDol) in Katowice [51] showed that the tower was not suitable for further vegetable and gardening production, while the further maintenance of the facility together with accompanying elements (gas boiler room and pumping station) and their maintenance and depreciation would absorb further financial resources. At the time of the decision about the demolition (1982), the value of buildings after deducting depreciation was estimated at:

- Greenhouse—PLZ 18.4 million;
- Boiler room—PLZ 1.6 million;
- Pumping station—PLZ 0.3 million.

These amounts would offset the cost of demolition after selling of materials, machinery and equipment.

The fact that the so-called Ruthner's Tower problem became very heated at certain points is evidenced by the consent to expand the expert team and the scope of work carried out given to the team leader, Eng. Jan Żarnowski in 1982 [51]. Eventually, the tower and its base were demolished in 1984, and from 1986, in its place a pavilion of gardening culture began to be constructed; it was never completed and was finally demolished in 2012.

4. Reflections on the History of the Vegetable and Gardening Tower in Chorzów

4.1. Reasons for Failure

The main reason for the failure of introducing vertical farming in Chorzów was primarily the incorrect selection of materials and technologies used for building the tower according to the environmental conditions prevailing in Upper Silesia. The vertical greenhouse design commissioned in Austria was developed for the country's environmental conditions and did not take into account the significant air pollution at the destination. The structure and coating of the building protected it improperly against the aggressive external environment; they were also not properly maintained and cleaned, and poor conditions of use only contributed to accelerating the process of degradation of the facility. However, most striking is the slowness in taking action to solve the problem of decreasing translucency of the outer shell of the building. Several years have passed from the moment the first problems with the cladding translucency were reported to the state, related to a lack of economically justified repair options according to the preserved correspondence.

The actual use of the tower was also a problem. The facility was used mainly for the internal purposes of WPKiW—production of seedlings for the needs of the park, and this did not facilitate the propagation of the idea of vertical farming as an innovation. Therefore, soon after opening, the building fell into oblivion. In situ research on the operation of the facility was not undertaken, relying only on Austrian experience. (Table 3)

Table 3. Parameters of gardening towers in Wiener Neustadt and Chorzów (developed by the authors based on [28,42,47,50,51]).

The City Where the Tower Was Located	Wiener Neustadt	Chorzów
Year of construction	1964	1965
Year of production shutdown	2006	1984
Year of demolition	2017	1984
The plan	Hexagonal, side length = 1.65	Round, diagonal = 11.2 m
Height	10.50 m	54 m
Load capacity	1800 kg	35,000 kg
Production	Ornamental plants	Ornamental plants
Orientation	East-West	
Assumed energy demand	21,000 kcal/h = 24.4 kW	710,000 kcal/h = 942 kW
Case	Glass (assembly without putty)	"PWS" polyester sheets
Reason for dismantling	Too high heating and maintenance costs, freeing up space for new investments	Destruction of the tower materials which were not properly adapted to the weather conditions and excessive heating and maintenance costs for the tower

The application of the vertical cultivation solution in the system proposed by Ruthner is, as recent supra-regional and global crises (epidemics, climate crisis, natural disasters) have shown, a way to solve the problem of direct availability of fresh food at the place of production in several specific situations. In the event of a significant increase in land prices and the associated food price, the use of a single tower causes a more than 12 times smaller demand for land. It also makes it possible, through complete isolation from the external environment, to use for cultivation purposes highly degraded areas which cannot be used for traditional agriculture (there are many such areas in Silesian cities). A relatively small amount of needed land (a vertical farm building with a base part occupied 22 × 25 m, i.e., a plot smaller than a typical one allocated for a detached house) and a fixed part with a

diameter of only 11.20 m allows for construction on a plot of essentially any shape. In the history of the Chorzów tower, the significant cost of heating the facility in the hydroponic cultivation system proposed by Ruthner and the cost of electricity needed to operate the mobile shelves were of great importance. In this case, the use of support systems providing renewable energy or partially artificial lighting would, to varying degrees depending on the location, reduce energy demand. As the earlier simulation showed, in terms of productivity, horticulture grown in the tower system yielded many times more than those grown on the same area in a tunnel system, i.e., with an extended vegetation cycle. Nevertheless, the costs for human labor are very similar in both cases, with an increased demand for energy.

In 1967, the energy consumption of 810,000 kcal/h (air heating) was planned and in the original design 710,000 kcal/h was assumed, which gives about 942 kW. At that time about 15 kW were needed to operate a single-family house. The high energy demand in relation to the relatively small size of the facility overlapped with the period of the energy crisis which prevailed in Europe, and was particularly palpable in Poland. At the time when the decision was taken to demolish the facility, its maintenance and energy consumption caused it to be considered extremely unprofitable, and its maintenance—uneconomical, although official information emphasized other aspects of this decision.

The tower in Chorzów operated for a relatively short amount of time. Its parameters with probably the longest functioning Ruthner gardening tower are compared below to illustrate the reasons for its failure.

There is a significantly higher energy demand assumed for the high tower in Silesia, which would most probably make it impossible to use the facility today if it still existed. This factor shows the advantage of a lower tower over a larger, seemingly more efficient tower.

Developing a comparative analysis with more examples and parameters would allow for a more in-depth understanding of the impact of tower heights on the energy demand and production capacity of Ruthner towers. This would allow for a better understanding of the potential and challenges of Othmar Ruthner's invention and how to adapt it. Such analysis is not the subject of this article.

4.2. The Potential of Ruthner's Tower in Chorzów

At the end of the 1960s, Upper Silesia was the apple of the eye of communist dignitaries. In the field of architecture, it was a place where much more was possible than in other parts of the country. The activities of architects like Henryk Buszka and Aleksander Franta, Maciej Gintowt and Maciej Krasiński, as well as the implementation of facilities innovative on a regional, but most of all—on a global scale—should be mentioned. Making Upper Silesia the area of modern, innovative new Poland required special treatment in the field of creating urban space and was associated, among others, with the possibility, but also the necessity of implementing innovative architecture in terms of both form and function, importing the latest technologies and implementing the most innovative creative thought. Hence, facilities such as the Spodek Arena, Millenium Housing Estate ('the Corn' skyscrapers) were built, but also Ruthner's Vegetable and Gardening Tower.

The pursuit of innovation by all means and the creation of Upper Silesia as the most modern area in the country in terms of architecture, among others, was often carried out against logic. The pursued goal was modernity itself, often in isolation from human needs and scale [52]. At this point, the real symbol of modernity became a bad or incomplete recognition of users' needs and was aimed mainly with a propaganda function. At the moment when it fulfilled this function, i.e., immediately after its construction and official commissioning, the tower began to serve as an auxiliary element, providing an economic and technical background for the park in which it was built, not as an innovative and experimental facility for the needs of the native urban agriculture.

The construction of the tower in the 1960s, i.e., at the time when the first assumptions of vertical farming were born, created an enormous propaganda potential for the development of the idea itself, which, however, was completely omitted, and the idea of vertical agriculture in Silesia—soon after implementation in Chorzów—abandoned.

Another, very similar facility functioning in Upper Silesia may have encountered a similar fate. The expansion of the Municipal Palm House in Gliwice, similarly to Ruthner's Tower, was supposed to impress with modernity and be a symbol of innovation in the approach to nature. The Municipal Palm House is located in the Chopin Park in Gliwice among the park greenery, just like the tower in Chorzów used to be. As the buildings and orangeries from the end of the 19th century were getting more and more damaged, architect Andrzej Musialik proposed to build a new structure around the existing ones, without having to replant the old trees. Inspired by the work of Philip Johnson, he proposed an innovative (on a Polish scale) structure, which was placed "outside" the building. According to the information which Musialik wrote down and transferred to the State Archive, the first projects were created as early as 1964 and the concept was developed in the years 1970–1980, with the support of the constructor Jan Polak [53].

The construction of the building lasted, with breaks, from 1982 to 1998. At that time, the entrance pavilion and platforms were redesigned by the architect Aleksander Skupin, who was involved in the construction of the building from 1992. The building consists of separate exhibition pavilions of different sizes and climatic conditions for storing plants. The basis of the projections is triangular, which is also indicated in the body of the building. The highest pavilion is 22 m high. A tubular, steel spatial truss was placed outside of the building, supporting polycarbonate glazing below it. It was decided to shape the building in such a way, assuming that it would be easier and safer to maintain steel elements exposed to the local weather conditions than to the climatic conditions adapted to the needs of plants in the pavilions [54]. The interiors are spacious and bright, and the structure casts a shadow into the building. Both during construction and the building's operation, further pavilions and exhibition spaces were added. At present, the building has five exhibition pavilions with plants, animals and aquariums and an entrance pavilion designed by Aleksander Skupin.

The tour of the exposure takes place on two levels (in situ, 17 April 2019). The upper platform placed about 4.5 m [53] above the floor; passing through successive pavilions allows to see the crowns of trees and plants from a different perspective than usual. The functional programme is complemented by a café and a floristry shop, which are located in the entrance pavilion. Despite the fact that the construction was interrupted for many years, this example shows that a facility of this type can function efficiently in a dense urban development, complementing the basic function with elements that were not included in the original design created in the 1970s. The introduction of service, commercial and recreational functions, matching the facility to the needs of the broadly understood culture of leisure time, has caused the building to function and surprise with its form until today (This is evidenced, among others, by the presentation of a model of the building at the exhibition "Identity. 100 years of Polish Architecture. Katowice 1989–2018" organized by the National Institute of Architecture and Urban Planning from 25 October to 15 December 2019. The building has also been described by the curator of the exhibition, Jakub Świerzawski, in the catalogue accompanying the exhibition).

5. Discussion

5.1. The Possibility of Adapting the Idea of Ruthner's Tower in Light Of Current Research and Implementation

Is it possible that in 1983, when the final decision on the demolition of the building was made, there were no means to adapt it to any other function? After all, examples of adaptation of post-industrial facilities for purposes not related to primary production were already known, and the pro-social aspect of this type of activity was already widely discussed in the architectural environment and beyond.

Research conducted on the currently non-existent vertical greenhouse in Chorzów and on the development of urban agriculture, and particularly on vertical farming, allow to conclude that at the time of making the decision to demolish the facility there were a number of potential solutions to prevent the demolition and to adapt the building to other purposes. At the same time, if the tower had not ceased to exist, it would have been one of the first in Europe and the earliest example of vertical farming in Poland.

Therefore, one can be tempted to analyze two cases: the first regarding the potential development and revitalization of the facility at the beginning of the 1980s in accordance with the technologies and demand available at the time, and the second assuming the continuous existence of the tower. In the latter case, the analysis includes current possibilities to improve and increase the economy of agricultural production of this type of building while maintaining its form and function.

It seems that the basic mistake that has been made consistently since the 1960s, which could have been successfully avoided—was creating the facility for the purpose of production only for the internal needs of the park. One can venture to say that a change in the production profile and growing food, like small greens, vegetables, and so on, intended for local residents or for the purpose of the restaurant that existed in the Voivodeship Park of Culture and Recreation in Chorzów, would cause an increase in interest in the facility, and perhaps also an improvement in its economic results.

It was also possible to rebuild the tower base and transform the freed space into a complementary function of commercial significance. Making it available to a wider group of users, also with a partial exposure of the farming technology in the ground floor, would have allowed for further dissemination and propagation of the idea of vertical farming among visitors of WPKiW.

Finally, an important element seems to be establishing and intensifying cooperation with research institutions, which on the one hand would have become another aspect justifying the tower's existence, and on the other would have enabled further development of knowledge about vertical agriculture as an interventional farming method for areas affected by heavy industry.

In the second of the considered cases (assuming the continuous existence of the tower), the range of possibilities for its renovation and revaluation becomes even greater. The first and most obvious would have been the replacement of the matted outer coating of the greenhouse and the introduction of elements improving the functioning of the farming system, including reducing its operating costs. Currently, using world experience, in a situation where the facility was to continue to perform only its original function, it would be possible to introduce systems supporting plant growth, including switching to an LED lighting system and replacing an inefficient heating system, as well as a significant improvement in the thermal insulation parameters of external panels.

It also seems important (as in the previous considered scenario) to transform the building of a tower base into a function commercializing production in line with the latest trends in creating multifunctional and active spaces (e.g., restaurant, bar, local food processing, temporary or permanent local market) would create the basis for ultimately transforming it into a center of nutritional and agricultural education.

5.2. Ruthner's Tower and Modern Solutions for Urban Vertical Farming

Whether the greenhouse towers designed by Othmar Ruthner have survived to this day or not, his ideas have been picked up and continued in the form of, among others, the idea of vertical farming. As early as 1966, in Ruefenach, Brugg, Switzerland, a horticultural tower based on Ruthner's solutions was built and was to be a more modern version of it. It was 18 m high and had an octagonal plan of 20 m^2. Irrigation and ventilation were automated to control the amount of light and temperature in the interior. The facility could accommodate 5500 potted plants. The full circulation of plants from bottom to top and back took 105 min at normal speed or 21 min in fast mode [53,55]. However, this prototype did not gain wider publicity [56]. The essence of Ruthner's invention is still very important. It was shown by the Museum of Technology in Vienna, which between June 2016 and June 2018 presented a model of Ruthner's Tower. It was part of an exhibition on the future of cities, drawing attention to the importance of the topic in the context of climate change and the changes faced by European cities [23,57].

The current direction taken by the development of urban agriculture causes the emergence of an increasing number of concepts and the implementation of facilities located in downtowns in densely built-up areas. The difference between them and the described tower is, however, that in modern implementations, as a rule, it is not possible to exclude their location from widespread use for the

purpose of conducting enclosed indoor farming. It refers to relatively small areas, including vertical agriculture. Numerous examples show the potential of the function of urban agriculture in creating community spaces. We are talking about introducing a new type of urban greenery, very often open to the public, also for the reconstruction and revitalization of areas that require it. Comparison with concepts developed for Paris, such as the vertical farm by ilimelgo architects and atelier secousses from 2016, or Agro-main-ville by ABF studio show a vertical division of functions and forms of facilities in such a way that at least the parts that are located on the ground floor create a public space open to people. It is often a dedicated space for selling locally cultivated food or additional elements. In comparison, the model of functioning of Ruthner's Tower seems to be poor and insufficient because it is limited only to agricultural production and maintenance of the technical background of this process.

6. Conclusions

At the time of its construction in Chorzów, the vertical greenhouse had enormous potential to initiate contemporary, or even avant-garde, urban farming in Poland. The first and so far the only comprehensive implementation of agricultural functions of this kind was a perfect example that it is possible, and most of all—reasonable, to implement urban agriculture in Poland. Although locating an enclosed, vertical farm in the middle of the park, in a huge open space contradicts the principles of creating urban farms, the facility itself was unique on a European scale.

Othmar Ruthner's Tower in Chorzów, through its location, mismatched materials and energy-consuming heating system, seems to have been a project doomed to failure. The location of the tower in such specific conditions makes it particularly important for research on vertical farms. New technologies are often shown in idealised conditions, which makes it difficult to check their boundary conditions. The examination of failures makes it possible to identify the way to success. In addition, research shows the great productive, scientific, popularising and touristic potential of the Ruthner Tower.

The reasons for the failure of an investment as innovative as an urban vertical farm in the concept of Ruthner's Tower can be found in planning errors. Local conditions and needs were not taken into account at this stage. The wider context, including the potential of technology brought to Poland, was not recognised or taken into account—this is evidenced by its location on the outskirts of an urban park, not in the city centre in an exposed and prestigious location, and by the subordinate function given to the facility after its construction. This resulted in a possible sluggishness in taking remedial measures and the lack of need for interventional protection of the facility. The tower was mainly used to manifest modernity as such, which is the result of the past political system, and became unnecessary when this potential was used up. The tower is an example of transferring Western architectural and technological solutions to Poland. This happened during the construction of exceptional, important and prestigious buildings in the region in the 1960s and 1970s. This is evidenced, among others, by the western downtown of Katowice, resembling the pedestrian passages from the UK of the 1950s and 1960s, a giant apartment block "Superjednotka" (designed by Mieczysław Król) referencing Le Corbusier's Marseille Unit, or the already mentioned Municipal Palm House in Gliwice [54].

The discussion, which can be traced back to the preserved full archival documentation during the period of the tower's existence, proves that adaptation to local conditions is essential for both technical and functional solutions. Availability, even just for exhibition purposes, for the inhabitants or local sales of the agricultural production, the availability of an experimental facility on a national scale for research purposes, i.e., causing the exchange of users of the facility, are only some of the basic factors increasing the durability of a facility in urban space.

These examples show that vertical farms require a very careful introduction to the site and should be treated as sensitive, innovative and highly complex in terms of functionality and technology. They require maintenance and special care in order to function in the long term. Like other machinery, they are strongly linked to the maintenance of technology and energy consumption and therefore need to be regularly upgraded and adapted to the conditions and available raw materials.

At this point, attention should also be paid to the aesthetics of Ruthner's towers. The example from Chorzów but also the example from WIG 64 prove that the gardening tower can be a prestigious undertaking. For a factory using new technology, the aesthetics of these examples seemed to match the aspirations of their creators. This means that vertical farms can be involved to some extent in architectural design considerations.

The example of the tower in Chorzów shows that the introduction of vertical agriculture in Poland is possible. However, it must be a thoughtful act and the building itself must be designed for the needs of a specific place and the environmental conditions in it, not just a political or marketing undertaking using a typical and patented solution. Undertaking such actions requires extensive economic, environmental, technical, social, architectural and urban planning analyses, which allow to place the new facility in the possibly broadly defined context. Therefore, building an urban agricultural system should be treated not only as purely technical action, but above all, as an architectural and urban planning activity, unique on a local and regional scale.

Although the preserved documentation clearly shows that the main reason for the deterioration of the technical condition of the facility, which eventually led to its demolition, were significant difficulties in carrying out renovation to the required extent (including replacement of the external cladding), but a broader analysis of the political, legal and social context of the uprising and functioning of the tower made from the current perspective allows us to believe that the greatest damage to the tower was caused by forgetfulness and lack of ideas for using the potential offered by the presence of one of the few vertical greenhouses in the world and the only one so easily accessible in Poland.

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